Recovery of In-Space CubeSat Experiments (RICE) Project

Bryan Chan[1],
Nicole Bauer[1],
Jessica R. Juneau[1],
Stephanie Stout[1],
Kento Masuyama[1],
Dave Spencer[1]

[1]Georgia Tech SSDL,
270 Ferst Dr.,
Atlanta, GA 30332, USA, bchan@gatech.edu,
nbauer3@gatech.edu, jjuneau3@gatech.edu,
sstout3@gatech.edu, kmasuyama@gatech.edu,
david.spencer@aerospace.gatech.edu

SSDL
Space Systems Design Laboratory

Mission Concept

The RICE project seeks to develop a low-cost, low-mass spacecraft that is capable of exposing scientific CubeSat experiments to the LEO space environment and safely recovering them for laboratory analysis on the ground. A CubeSat-sized payload was selected because of its standard interface system that is widely used by university programs and the aerospace industry.

The mission architecture is depicted below in Figure 1, including the launch, on-orbit operations, EDL (entry, descent, and landing) and recovery phases of the mission.

Trade Studies

To select the entry vehicle geometry, a quantitative survey of four possible geometries was completed (Mars Microprobe, Sphere, CEV, and Stardust). The Mars Microprobe 45° spherecone geometry was selected due to its excellent stability, flight heritage, and overall simplicity. Figure 2 is a model of the overall packaging scheme. The deceleration method was also determined to be a subsonic parachute, as seen in the following table.

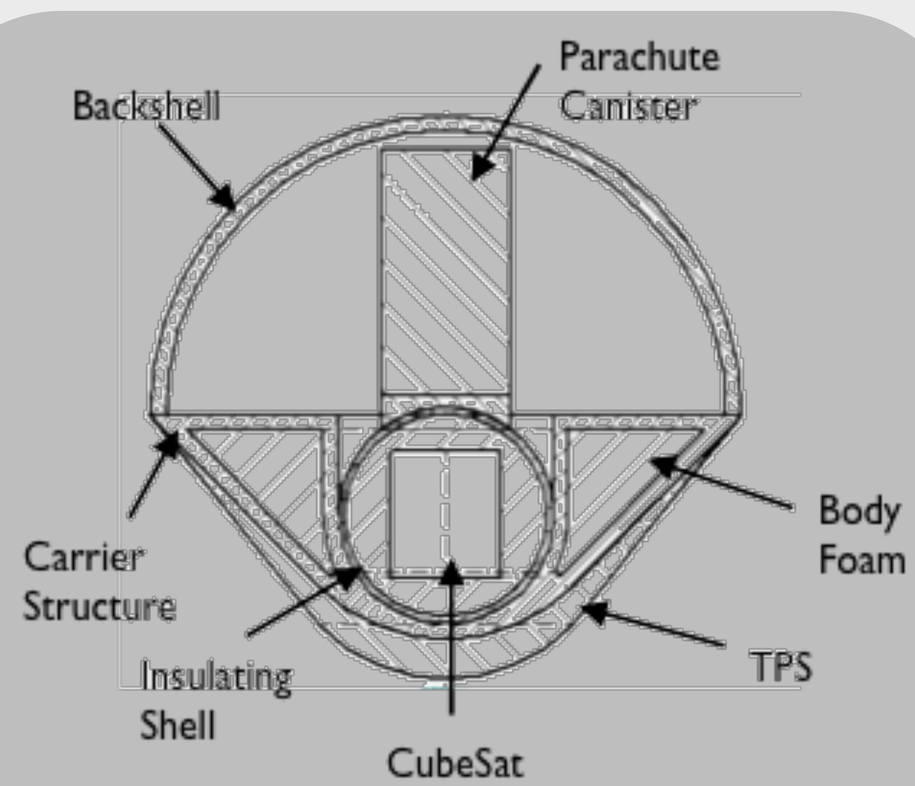

Figure 2. *Entry Vehicle packaging model.*

Deceleration Methods		
Method	*Impact Acceleration*	*Results*
Carbon Foam Impact Sphere	161-281 g	Acceleration too high for most science payloads
Subsonic Parachute	8.43 g	Need to investigate canister geometry and deployment strategy

Science Rationale

A panel of scientists was formed to brainstorm possible missions for the RICE system. The table below details information gathered from them.

Reference Mission	Microorganism in Microgravity/ Radiation	Snails in Microgravity/ Radiation	Human Tissue in Microgravity/ Radiation
Science Objective	*Determine effects of microgravity on live animal development.*		
Science Priority	*Informs decisions on the design of exploration mission systems.*		
Volume	*Min: 1 U; 2U greatly increases capability*	*Minimum: 2U*	*Min: 1 U; 2U greatly increases capability*
Mass	*Min: 1 kg, 3-4 kg greatly increases capability*	*Minimum: 3-4 kg*	*Min: 1 kg, 3-4 kg greatly increases capability*
Thermal Management	*20-25 C thermal control provided to CubeSat surface*	*10-40 C thermal control provided to CubeSat surface*	*20-25 C provided to CubeSat surface (need 37 +/- 0.1 deg C at sample)*
Environmental Exposure	*Microgravity, high inclination orbits will have high radiation exposure*		
On-Orbit Life	*20-60 days or more is desirable to increase radiation exposure*		
Max Recovery Time	*6 hours*		
Static Inertial Loading	*At least Bion flight profile*		
Dynamic Inertial Loading	*<6.0 - 7.5 g rms (below 30 Hz). Above 30Hz, there is very little coupling to biological systems*		
Total Electrical Energy	*4 W for TCs/ fine tuning thermal control, <20 W peak during rapid heating cycle*	*4-10 W of power [est.]*	*4-10 W of power [est.]*
Data Storage	*500 MB of monitoring environmental data*		
Comms	*Real time temperature monitoring (updates at least every 6 hrs)*		
Launch Integration Time	*3 weeks*		

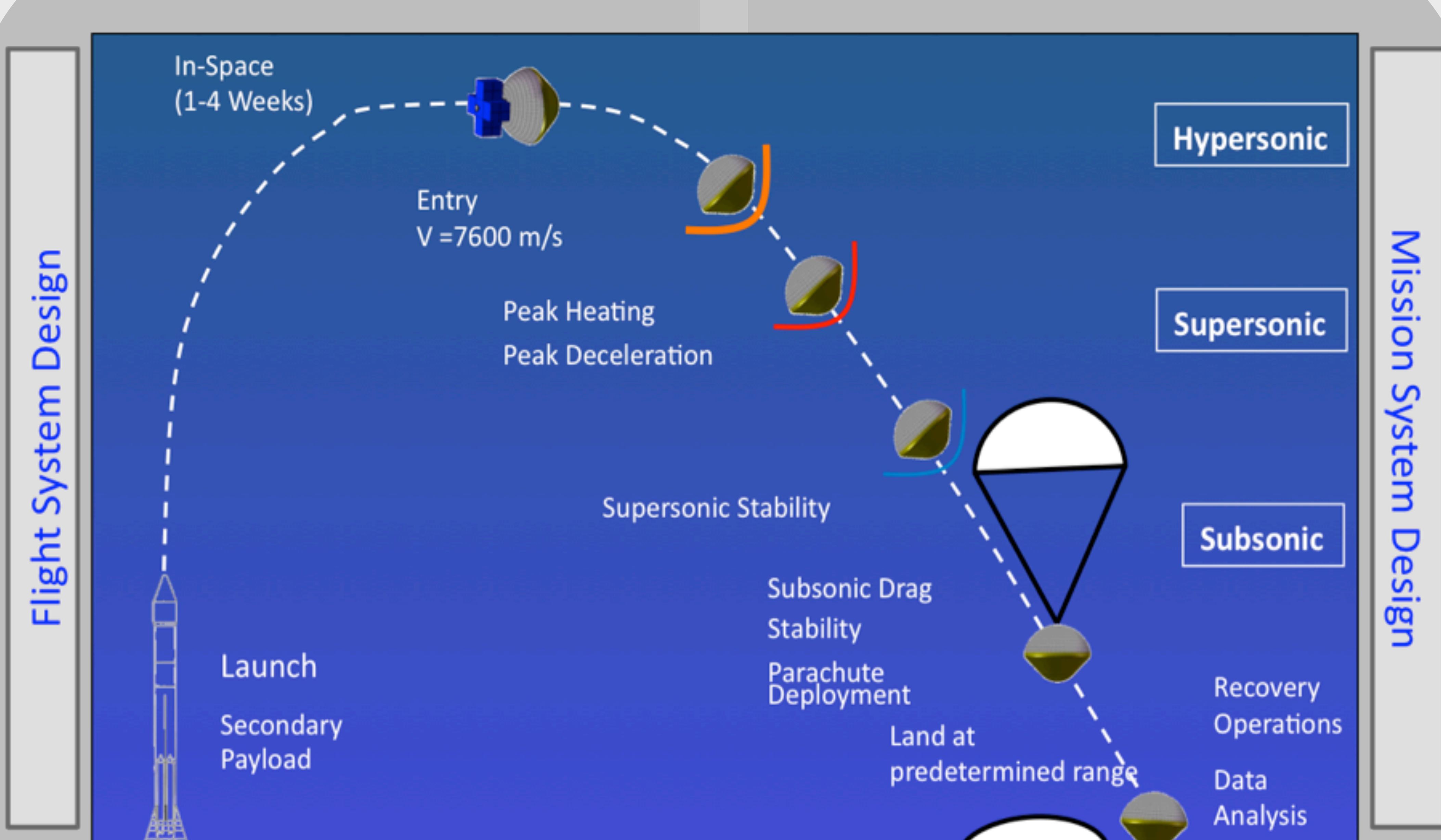

Figure 1. *The RICE mission architecture will consist of four stages: launch; on-orbit operations; entry, descent, and landing; and recovery. The system will be injected into a low-earth orbit for 1-4 weeks, when the vehicle will then perform a de-orbit maneuver and the service module will separate from the entry vehicle. The entry vehicle will follow a ballistic trajectory until a subsonic parachute is deployed. The capsule will be quickly recovered upon ground impact, where it can be taken to the lab for analysis.*

RICE Flight System

Baseline Design

The objective that the RICE system shall favor simplicity leads to the selection of mission cost and spacecraft mass as the primary drivers. Therefore, the RICE system will be launched as a secondary payload, and the 30-kg NanoSat class will be targeted in order to launch within the RideShare Adapter (RSA), seen in Figure 3. For the baseline mission orbit, the simplest case was selected: low-earth, circular orbit (see Figure 4).

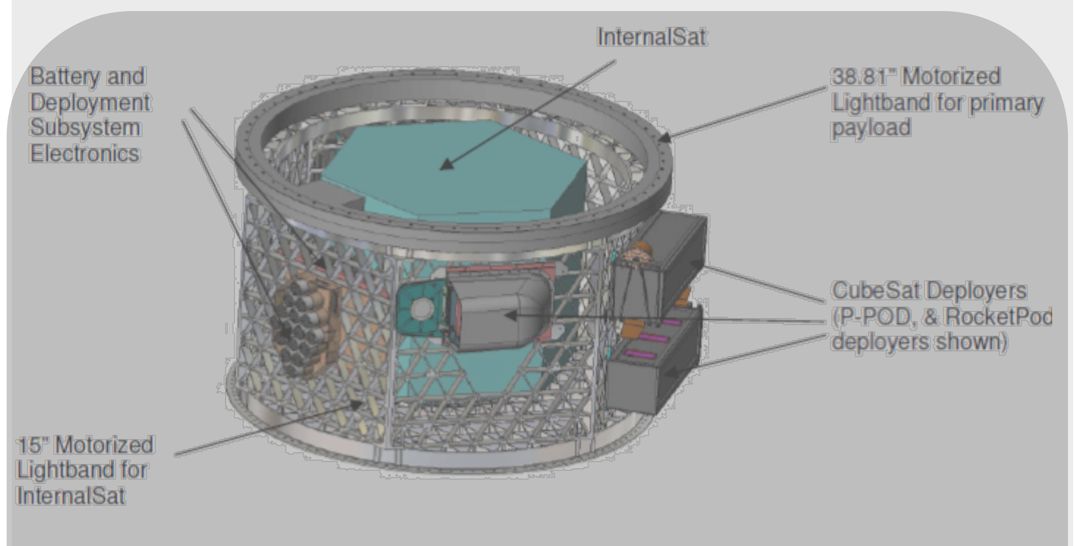

Figure 3. *The RSA uses a lightband separation system and is currently manufactured for the Falcon 1 and is in development for the Taurus II, Minotaur 1, Minotaur IV, Falcon 9, Atlas V, and Delta IV.*

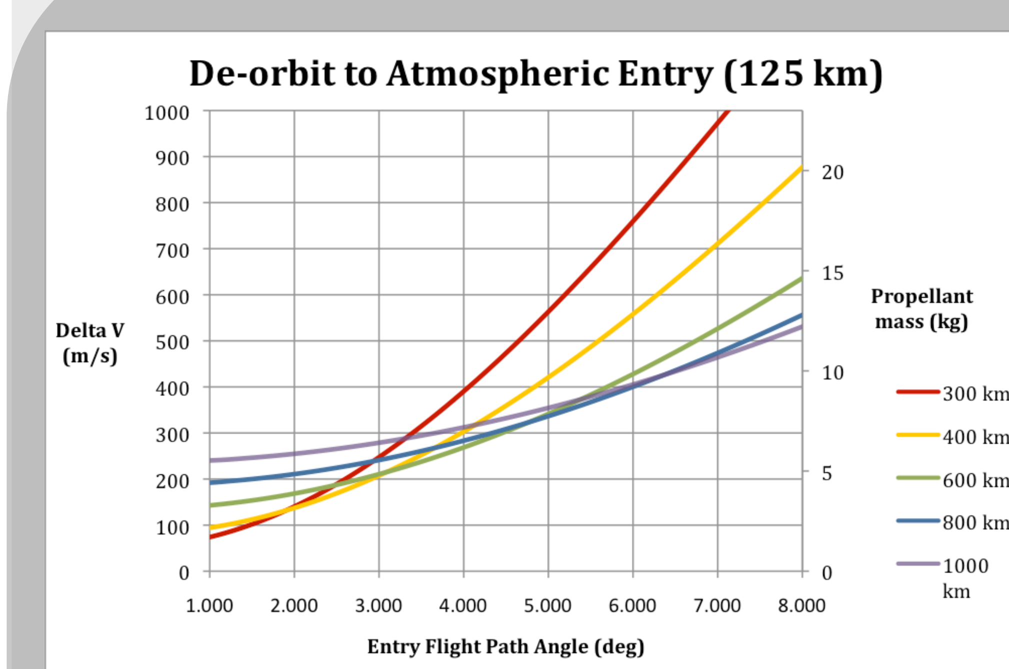

Figure 4. *The propellant mass for the range of -3 to -4 degrees was found to be relatively constant for orbits between 300km and 1000km. Therefore, that range of altitudes was chosen as the baseline to be examined in all future analyses.*

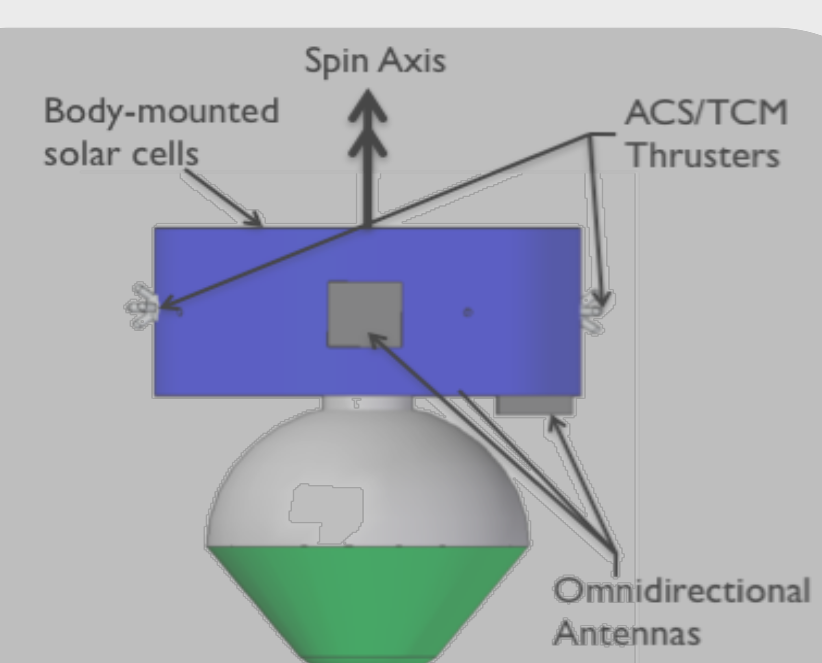

Figure 5. *The baseline spacecraft design will be spin-stabilized, have 8 microthrusters, and 3 omni-directional antennas.*

Acknowledgements

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